

CLAIMS

1. A corrosion-inhibiting conversion coating comprising a rare earth element and a valence stabilizer combined to form a rare earth/valence stabilizer complex, wherein

the rare earth element is selected from cerium, praseodymium, terbium, or a combination thereof, and

at least one rare earth element is in the tetravalent oxidation state.

2. The conversion coating of claim 1 wherein the rare earth/valence stabilizer complex has a solubility in water of between about  $5 \times 10^{-1}$  and about  $1 \times 10^{-5}$  moles per liter of cerium, praseodymium, or terbium at about 25°C and about 760 Torr.

3. The conversion coating of claim 2 wherein the solubility of the rare earth/valence stabilizer complex in water is between about  $5 \times 10^{-2}$  and about  $5 \times 10^{-5}$  moles per liter of cerium, praseodymium, or terbium at about 25°C and about 760 Torr.

4. The conversion coating of claim 1 wherein there is an electrostatic barrier layer around the rare earth/valence stabilizer complex in aqueous solution.

5. The conversion coating of claim 1 wherein the rare earth/valence stabilizer complex acts as an ion exchange agent towards corrosive ions.

6. The conversion coating of claim 1 wherein the conversion coating is between about 25 and about 10,000 nanometers thick.

7. The conversion coating of claim 6 wherein the conversion coating is between about 100 and about 500 nanometers thick.

8. The conversion coating of claim 1 wherein the conversion coating has a morphology which enhances adhesion of a coating applied over the conversion coating.

9. The conversion coating of claim 1 wherein the rare earth/valence stabilizer complex has a central cavity containing a cerium, praseodymium, or terbium ion and an additional ion.

10. The conversion coating of claim 9 wherein the additional ion is  $B^{+3}$ ,  $Al^{+3}$ ,  $Si^{+4}$ ,  $P^{+5}$ ,  $Ti^{+4}$ ,  $V^{+5}$ ,  $V^{+4}$ ,  $Cr^{+6}$ ,  $Cr^{+3}$ ,  $Mn^{+4}$ ,  $Mn^{+3}$ ,  $Mn^{+2}$ ,  $Fe^{+3}$ ,  $Fe^{+2}$ ,  $Co^{+2}$ ,  $Co^{+3}$ ,  $Ni^{+2}$ ,  $Ni^{+3}$ ,  $Ni^{+4}$ ,  $Cu^{+2}$ ,  $Cu^{+3}$ ,  $Zn^{+2}$ ,  $Ga^{+3}$ ,  $Ge^{+4}$ ,  $As^{+5}$ ,  $As^{+3}$ , or  $Zr^{+4}$ .

11. The conversion coating of claim 1 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

12. The conversion coating of claim 11 wherein the valence stabilizer is the inorganic valence stabilizer selected from molybdates, tungstates, vanadates, niobates, tantalates, tellurates, periodates, iodates, carbonates, antimonates, stannates, phosphates, nitrates, bromates, sulfates, titanates, zirconates, bismuthates, germanates, arsenates, selenates, borates, aluminates, silicates, or combinations thereof.

13. The conversion coating of claim 12 wherein the valence stabilizer is the inorganic valence stabilizer selected from molybdates, tungstates, vanadates, niobates, tantalates, tellurates, periodates, iodates, carbonates, antimonates, stannates, phosphates, nitrates, bromates, sulfates, or combinations thereof.

14. The conversion coating of claim 11 wherein the valence stabilizer is the organic valence stabilizer selected from monoamines; diamines; triamines; tetraamines; pentamines; hexamines; five- or six-membered heterocyclic rings containing one to four nitrogen atoms optionally having additional nitrogen, sulfur, or oxygen binding sites; five- or six-membered heterocyclic rings containing one or two sulfur atoms and having additional nitrogen binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and having additional nitrogen binding sites; (two-, three-, four-, six-, eight-, or ten-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; macrocyclic oligothioketones or dithiolenes; diazenes; thio-, amido-, or imido-derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; thio-derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; azo compounds,

triazenes, formazans, azines, hydrazones, or Schiff Bases containing at least two azo, imine, or azine groups; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases; ortho- (for aryl) or alpha- or beta- (for alkyl) substituted azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases; oximes; amidines and imido compounds; dithio ligands; amides; amino acids; N-(thio)acyl 7-aminobenzylidenimines; (thio)hydroxamates; alpha- or ortho- aminothio(di)carboxylic acids and salts; (thio)semicarbazones; (thio)acyl hydrazones; (thio)carbazones; silylaminoalcohols; thioalkyl amines and imines; hydroxyalkyl imines; (thio)aryl amines and imines; guanylureas; guanidinoureas; 2-nitrosophenols; 2-nitrophenols; N-nitrosohydroxylamines; 1,3-monothioketones; monothiomalonamides; 2-thioacylacetamides; 2-acylthioacetamides; dithiodicarbonic diamides; trithiodicarboxylic acids and salts; monothiocarbamates; monothioethers; dithioethers; trithioethers; tetrathioethers; pentathioethers; hexathioethers; disulfides; monophosphines; diphosphines; triphosphines; tetraphosphines; pentaphosphines; hexaphosphines; five- or six-membered heterocyclic rings containing one or two sulfur atoms optionally having additional sulfur, oxygen, or phosphorus binding sites; five- or six-membered heterocyclic rings containing one to three phosphorus atoms optionally having additional phosphorus, nitrogen, oxygen, or sulfur binding sites; five- or six-membered heterocyclic rings containing one to four nitrogen atoms and having additional phosphorus binding sites; five- or six-membered heterocyclic rings containing one or two oxygen atoms and optionally having additional sulfur or phosphorus binding sites; (five-, seven-, or nine-)membered nitrogen, nitrogen-sulfur, or nitrogen-oxygen macrocyclics; (two- to ten-)membered sulfur, sulfur-oxygen, or sulfur-phosphorus macrocyclics, not including oligothioketones or dithiolenes; (two- to ten-)membered phosphorus, nitrogen-phosphorus, or oxygen-phosphorus macrocyclics; (two- to ten-)membered oxygen macrocyclics; thio-, amido-, or imido-derivatives of phosphonic and diphosphonic acids and salts containing no sulfur binding sites; amido-, or imido-derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts containing no sulfur binding sites; dithioperoxydiphosphoramides; dithioperoxydiphosphoric acids and salts; monothioperoxydiphosphoramides; monothioperoxydiphosphoric acids and salts; monothio phosphoric acids; phosphoro(dithioperoxoic) acids and salts; azo compounds, triazenes, formazans, azines, or Schiff Bases; silylamines; silazanes; guanidines and diguanidines; pyridinaldimines; hydrazones; hydramides; nitriles; thioureas and thioamides; ureas and pseudoureas; biurets; monothio ligands; diketone ligands; dithioperoxydicarbonic acids and salts;

dithioacyl disulfides; tetrathioperoxydicarbonic diamides; (hexa-, penta-, or tetra-  
 )thioperoxydicarbonic acids and salts; 1,2-dithiolates; rhodanines; dithiocarbimates;  
 (thio)xanthates; S-(alkyl- or aryl-thio)thiocarboxylic acids and salts; phosphinodithioformates;  
 (thio)borates and (thio)boronates; (thio)arsonic acids and salts; (thio)antimonic acids and salts;  
 5 phosphine and arsine sulfides or oxides; beta-hydroxyketones and -aldehydes; squaric acids and  
 salts; carbonates; carbamates and carbimates; carbazates; imidosulfurous diamides;  
 sulfurdiimines; thiocarbonyl and mercapto oximes; 2-nitrothiophenols; 2-nitrilo(thio)phenols;  
 acylcyanamides; imidates; 2-amidinoacetates; beta-ketoamines; 3-aminoacrylamides and 3,3-  
 diaminoacrylamides; 3-aminoacrylic acids and salts and 3-hydroxy-3-aminoacrylic acids and  
 10 salts; 2-nitroanilines; amine and diazine N-oxides; hydrazides and semicarbazides; (amino- or  
 imino-)aryl phosphines; (thio- or hydroxy-)aryl phosphines; arsines; five- or six-membered  
 heterocyclic rings containing one arsenic atom optionally having additional arsenic binding sites;  
 (two- to six-)membered arsenic macrocyclics; selenoethers; five- or six-membered heterocyclic  
 rings containing one or two selenium atoms optionally having additional selenium binding sites;  
 15 (two- to six-)membered selenium macrocyclics; 1,3-diselenoketones; 1,1-diselenolates;  
 diselenocarbamates; selenophosphoric acids and salts; selenocarbonates; cyanide, isocyanide,  
 and cyanamide ligands; nitrosyl and nitrite ligands; azide ligands; thiolates and selenolates;  
 (thio)cyanate ligands; diene or bicyclic or tricyclic hydrocarbon ligands; carbonyl, halogen, oxo,  
 and hydroxo ligands; or combinations thereof.

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 15. The conversion coating of claim 14 wherein the organic valence stabilizer is selected  
 from monoamines; diamines; triamines; tetraamines; pentamines; hexamines; five- or six-  
 membered heterocyclic rings containing one to four nitrogen atoms optionally having additional  
 nitrogen, sulfur, or oxygen binding sites; five- or six-membered heterocyclic rings containing  
 25 one or two sulfur atoms and having additional nitrogen binding sites; five- or six-membered  
 heterocyclic rings containing one or two oxygen atoms and having additional nitrogen binding  
 sites; (two-, three-, four-, six-, eight-, or ten-)membered nitrogen, nitrogen-sulfur, or nitrogen-  
 oxygen macrocyclics; macrocyclic oligothioketones or dithiolenes; diazenes; thio-, amido-, or  
 imido-derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; azo  
 30 compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases containing at least two  
 azo, imine, or azine groups; azo compounds, triazenes, formazans, azines, hydrazones, or Schiff

Bases; ortho- (for aryl) or alpha- or beta- (for alkyl) substituted azo compounds, triazenes, formazans, azines, hydrazones, or Schiff Bases; oximes; amidines and imido compounds; dithio ligands; amides; amino acids; N-(thio)acyl 7-aminobenzylidenimines; (thio)hydroxamates; alpha- or ortho-aminothio(di)carboxylic acids and salts; (thio)semicarbazones; (thio)acyl hydrazones; (thio)carbazones; silylaminoalcohols; thioalkyl amines and imines; hydroxyalkyl imines; (thio)aryl amines and imines; guanylureas; guanidinoureas; biurets; diketone ligands; amido- or imido-derivatives of hypophosphoric, phosphoric, or diphosphoric acids and salts; beta-hydroxyketones and -aldehydes; squaric acids and salts; carbonates; carbamates and carbimates; 2-nitrosophenols; 2-nitrophenols; N-nitrosohydroxylamines; 1,3-monothioketones; monothiomalonamides; 2-thioacylacetamides; 2-acylthioacetamides; dithiodicarbonyl diamides; trithiodicarboxylic acids and salts; monothiocarbamates; (thio)cyanate ligands; or combinations thereof.

16. The conversion coating of claim 14 wherein the organic valence stabilizer is the diazene selected from diazeneformimidamides, diazeneformamides, diazeneformothioamides, diazeneacetimidamides, diazeneacetothioamides, diazeneformimidic acids and salts, diazeneacetimidic acids and salts, diazenecarbothioic acids and salts, diazenecarbodithioic acids and salts, diazeneformimidothioic acids and salts, diazeneformaldehydes, diazeneformothioaldehydes, diazeneacetaldehydes, diazeneacetothioaldehydes, diazenediformamides, diazenediformothioamides, diazenediacetamides, diazenediacetothioamides, diazeneacetimidothioic acids and salts, imidoaldiazenes, diazenediformimidamides, diazenediacetimidamides, diazenediformimidic acids and salts, diazenediacetimidic acids and salts, diazenediformimidothioic acids and salts, diazenediacetimidothioic acids and salts, diazenedicarbothioic acids, diazenedicarbodithioic acids, diazeneformic acids, diazenediformic acids, diazeneacetic acids, diazenediacetic acids, diazenediformaldehydes, diazenediformothioaldehydes, diazenediacetaldehydes, diazenediacetothioaldehydes, diimidoaldiazenes, or combinations thereof.

17. The conversion coating of claim 14 wherein the organic valence stabilizer is the thio-, amido-, or imido-derivative of hypophosphoric, phosphoric, or diphosphoric acids and salts selected from phosphoramidimidic triamides, phosphoramidimidic acids and salts,

phosphorodiamidimidic acids and salts, phosphorodiamidimidothioic acids and salts,  
phosphoramidimidothioic acids and salts, phosphorodiamidimidodithioic acids and salts,  
phosphoramidimidodithioic acids and salts, (di- or mono-)thiohypophosphoric acids and salts,  
(di- or mono-)thiohypophosphoramides, phosphoramidic acids and salts, phosphorimidic acids  
5 and salts, (di- or mono-)thioimidodiphosphoric acids and salts, (di- or mono-  
)thiohydrazidodiphosphoric acids and salts, (di- or mono-)thioimidodiphosphoramides, (di- or  
mono-)thiohydrazidodiphosphoramides, phosphoric triamides, (di- or mono-  
)thiodiphosphoramides, (di- or mono-)thiodiphosphoric acids and salts, (tetra-, tri-, di-  
)thiophosphoric acids and salts, phosphoro(dithioperoxo)(mono-, di-, or tri-)thioic acids and salts,  
10 phosphorimido(mono-, di-, or tri-)thioic acids and salts, phosphorothioic triamides,  
phosphoramido(mono, di- or tri-)thioic acids and salts, phosphorodiamido(mono, di- or tri-  
)thioic acids and salts, or combinations thereof.

18. The conversion coating of claim 14 wherein the organic valence stabilizer is the ortho-  
15 (for aryl) or alpha- or beta- (for alkyl) substituted azo compound, triazene, formazan, azine,  
hydrazone, or Schiff Base having a substituent selected from amino, imino, oximo, diazeno,  
hydrazido, thiol, mercapto, thiocarbonyl, hydroxy, carbox, and carbonyl substituents, or  
combinations thereof.

19. The conversion coating of claim 14 wherein the organic valence stabilizer is the oxime  
20 selected from monooximes, dioximes, carbonyl oximes, imine oximes, hydroxy oximes, amino  
oximes, amido oximes, hydrazone oximes, azo oximes, or combinations thereof.

20. The conversion coating of claim 14 wherein the organic valence stabilizer is the amidine  
25 and imido compound selected from amidines, diamidines, biguanides, biguanidines,  
diamidinomethanes, imidoylguanidines, amidinoguanidines, diformamidine oxides,  
diformamidine sulfides, diformamidine disulfides, imidodicarbonimidic acids and salts,  
diimidodicarbonimidic acids and salts, thioimidodicarbonimidic acids and salts,  
thiodiimidodicarbonimidic acids and salts, diimidoylimines, diimidoylhydrazides,  
30 imidosulfamides, diimidosulfamides, O-amidinocarbamates, O- or S-amidino(mono-, di-, or

peroxy-)thiocarbamates, N-hydroxy(or N,N'-dihydroxy)amidines, diimidosulfuric acids and salts, or combinations thereof.

21. The conversion coating of claim 14 wherein the organic valence stabilizer is the dithio  
5 ligand selected from dithioimidodialdehydes, dithiohydrazidodialdehydes, dithioimidodicarbonic  
acids and salts, dithiohydrazidodicarbonic acids and salts, 1,3-dithioketones, 1,2-dithioketones,  
dithiomalonamides, 2-thioacylthioacetamides, dithioacyl sulfides, trithiodicarbonic diamides,  
(penta-, tetra-, tri-)thiodicarbonic acids and salts, beta-mercaptothioketones and -aldehydes, N-  
(aminomethylthiol)thioureas, dithiooxamides, 1,1-dithiolates, (di- or per-)thiomonocarboxylic  
10 acids and salts, (tetra- or per-)thiodicarboxylic acids and salts, (di-, tri-, or per-)thiocarbonates,  
dithiocarbamates (including N-hydroxydithiocarbamates and N-mercaptodithiocarbamates),  
dithiocarbazates, or combinations thereof.

22. The conversion coating of claim 14 wherein the organic valence stabilizer is the amide  
15 selected from monoamides, lactams, amidinoamides, guanidinoamides, imidoalamides,  
polyamides, polylactams, or combinations thereof.

23. The conversion coating of claim 14 wherein the organic valence stabilizer is the thio-,  
amido-, or imido-derivative of phosphonic and diphosphonic acids and salts selected from  
20 phosphonitrile amides, phosphonimidic diamides, phosphonamidimidic acids and salts,  
phosphonamidimidothioic acids and salts, dithioimidodiphosphonic acids and salts,  
dithiohydrazidodiphosphonic acids and salts, dithioimidodiphosphonamides,  
dithiohydrazidodiphosphonamides, dithiodiphosphonamides, dithiodiphosphonic acids and salts,  
dithioperoxydiphosphonamides, dithioperoxydiphosphonic acids and salts, (di- and tri-  
25 )thiophosphonic acids and salts, phosphono(dithioperoxo)thioic acids and salts,  
phosphono(dithioperoxo)dithioic acids and salts, phosphonimidothioic acids and salts,  
phosphonimidodithioic acids and salts, phosphonothioic acids and salts, phosphonanidothioic  
acids and salts, phosphonamidimidodithioic acids and salts, monothioimidodiphosphonic acids  
and salts, monothiohydrazidodiphosphonic acids and salts, monothioimidodiphosphonamides,  
30 monothiohydrazidodiphosphonamides, monothiodiphosphonamides, monothiodiphosphonic  
acids and salts, monothioperoxydiphosphonamides, monothioperoxydiphosphonic acids and

salts, monothiophosphonic acids and salts, phosphono(dithioperoxoic) acids and salts, or combinations thereof.

24. The conversion coating of claim 14 wherein the organic valence stabilizer is the amido-  
or imido-derivative of hypophosphoric, phosphoric, or diphosphoric acids and salts containing  
no sulfur binding sites selected from hypophosphoric acids and salts, hypophosphoramides,  
imidodiphosphoric acids and salts, hydrazidodiphosphoric acids and salts,  
imidodiphosphoramides, hydrazidodiphosphoramides, diphosphoramides, or combinations  
thereof.

25. The conversion coating of claim 14 wherein the organic valence stabilizer is the amido-  
or imido-derivative of phosphonic or diphosphonic acids and salts containing no sulfur binding  
sites selected from imidodiphosphonic acids and salts, hydrazidodiphosphonic acids and salts,  
imidodiphosphonamides, hydrazidodiphosphonamides, diphosphonamides, phosphonimidic  
acids and salts, phosphonamidic acids and salts, phosphonic diamides, or combinations thereof.

26. The conversion coating of claim 14 wherein the organic valence stabilizer is the thiourea  
and thioamide selected from thioureas, thiocarboxamides, thioacylthioureas, acylthioureas,  
thioacylureas, thioaroylthioureas, aroylthioureas, thioaroylureas, thioimides, thioguanylureas,  
guanidinothioureas, amidinothioamides, guanidinothioamides, imidothioamides, 3-  
aminothioacrylamides, thiohydrazides, thiosemicarbazides, (mono- and di-)thiobiurets, (mono-  
and di-)thioisobiurets, (mono- and di-)thiobiureas, N-(aminomethylol)thioureas, N-  
(aminomethylthiol)ureas, beta-mercaptocarboxamides, or combinations thereof.

27. The conversion coating of claim 14 wherein the organic valence stabilizer is the biuret  
selected from biurets, triurets, isobiurets, biureas, triureas, acylureas, aroylureas, N-  
(aminomethylol)ureas, or combinations thereof.

28. The conversion coating of claim 14 wherein the organic valence stabilizer is the  
monothio ligand selected from beta-aminothiones, 3-aminothioacrylic acids and salts, 3-  
mercapto-3-aminothioacrylic acids and salts, N-thioacyl benzylidenimines,



thioimidodialdehydes, thiohydrazidodialdehydes, thioimidodicarbonic acids and salts, thiohydrazidodicarbonic acids and salts, 1,2-monothioketones, trithioperoxydicarbonic diamides, dithioperoxydicarbonic diamides, dithiodicarbonic acids and salts, trithioperoxydicarbonic acids and salts, beta-hydroxythioketones, beta-hydroxythioaldehydes, beta-mercaptoketones, beta-mercaptoaldehydes, monothiooxamides, beta-mercaptocarboxylic acids and salts, beta-mercaptothiocarboxylic acids and salts, beta-hydroxythiocarboxylic acids and salts, S-alkylthiocarboxylic acids and salts, S-arylthiocarboxylic acids and salts, S-alkyldisulfidocarboxylic acids and salts, S-aryldisulfidocarboxylic acids and salts, monothiomonocarboxylic acids and salts, dithiodicarboxylic acids and salts, monothiocarbonates, monothiocarbazates, monothiocarbimates, mercaptoalcohols, silylmercaptoalcohols, or combinations thereof.

29. The conversion coating of claim 14 wherein the organic valence stabilizer is the diketone ligand selected from imidodialdehydes, hydrazidodialdehydes, imidodicarbonic acids and salts, hydrazidodicarbonic acids and salts, imidodisulfamic acids and salts, imidodisulfuric acids and salts, 1,3-diketones, 1,3,5-triketones, 1,2-diketones, 1,2,3-triketones, tropolonates, ortho-quinones, malonamides, 2-acylacetamides, monothiodicarbonic diamides, monothiodicarbonic acids and salts, trithionic acids and salts, oxamides, dicarboxylic acids, or combinations thereof.

30. The conversion coating of claim 14 wherein the organic valence stabilizer is the S-(alkyl- or aryl-thio)thiocarboxylic acid and salt selected from S-(alkylthio)thiocarboxylic acids and salts, S-(arylthio)thiocarboxylic acids and salts, S,S-thiobisthiocarboxylic acids and salts, S-(alkyldisulfido)thiocarboxylic acids and salts, S-(aryldisulfido)thiocarboxylic acids and salts, S,S'-disulfidobisthiocarboxylic acids and salts, or combinations thereof.

31. The conversion coating of claim 14 wherein the organic valence stabilizer is the phosphine and arsine sulfide or oxide selected from phosphine P-sulfides, aminophosphine sulfides, arsine As-sulfides, aminoarsine sulfides, phosphine P-oxides, aminophosphine oxides, arsine As-oxides, aminoarsine oxides, or combinations thereof.

32. The conversion coating of claim 14 wherein the solubility in water of the rare earth/valence stabilizer complex is adjusted by an addition of a substituent group on the organic valence stabilizer.

5 33. The conversion coating of claim 32 wherein the solubility in water is increased by the addition of the substituent group selected from sulfonate groups ( $-\text{SO}_3^-$ ), carboxyl groups ( $-\text{CO}_2^-$ ), hydroxyl groups ( $-\text{OH}$ ), ester groups ( $-\text{CO}_3^-$ ), carbonyl groups ( $=\text{C}=\text{O}$ ), amine groups ( $-\text{NH}_2$ ), nitrosamine groups ( $=\text{N}-\text{N}=\text{O}$ ), carbonylnitrene groups ( $-\text{CO}-\text{N}$ ), sulfoxide groups ( $=\text{S}=\text{O}$ ), sulfone groups ( $=\text{S}=[\text{O}]_2$ ), sulfinyl groups ( $-\text{N}=\text{S}=\text{O}$ ), sulfodiimines ( $=\text{S}=[\text{NH}]_2$ ), sulfonyl halide  
10 groups ( $-\text{S}=[\text{O}]_2\text{X}$ ), sulfonamide groups ( $-\text{S}=[\text{O}]_2\text{NH}_2$ ), monohalosulfonamide groups ( $-\text{S}=[\text{O}]_2\text{NHX}$ ), dihalosulfonamide groups ( $-\text{S}=[\text{O}]_2\text{MX}_2$ ), halosulfonate groups ( $-\text{S}=[\text{O}]_2\text{OX}$ ), halosulfonate amide groups ( $=\text{N}-\text{S}=[\text{O}]_2\text{X}$ ), aminosulfonate groups ( $=\text{N}-\text{S}=[\text{O}]_2\text{OH}$ ), iminosulfonate groups ( $-\text{N}[\text{SO}_3^-]_{1-2}$ ), phosphonate groups ( $-\text{PO}_3^{-2}$ ), phosphonamide groups ( $-\text{PO}_2\text{NH}_2^-$ ), phosphondiamide groups ( $-\text{PO}[\text{NH}_2]_2$ ), aminophosphonate groups ( $=\text{N}-\text{PO}_3^{-2}$ ),  
15 iminophosphonate groups ( $-\text{N}[\text{PO}_3^{-2}]_{1-2}$ ), or combinations thereof.

34. The conversion coating of claim 32 wherein the solubility in water is decreased by the addition of the substituent group selected from nitro groups ( $-\text{NO}_2$ ), perfluoroalkyl groups ( $-\text{C}_x\text{F}_{2x+1}$ ), perchloroalkyl groups ( $-\text{C}_x\text{Cl}_{2x+1}$ ), nitramine groups ( $=\text{N}-\text{NO}_2$ ), thioketone groups  
20 ( $=\text{C}=\text{S}$ ), sulfenyl halide groups ( $-\text{S}-\text{X}$ ), sulfur dihaloimide groups ( $-\text{N}=\text{SX}_2$ ), or combinations thereof.

35. The conversion coating of claim 14 wherein an electrostatic barrier layer of the rare earth/valence stabilizer complex is adjusted by an addition of a substituent group on the organic  
25 valence stabilizer.

36. The conversion coating of claim 35 wherein the electrostatic barrier layer is increased by the addition of the substituent group selected from ketones ( $=\text{C}=\text{O}$ ), thioketones ( $=\text{C}=\text{S}$ ), amides ( $-\text{C}[\text{O}]-\text{NR}_2$ ), thioamides ( $-\text{C}[\text{S}]-\text{NR}_2$ ), nitriles or cyano groups ( $-\text{CN}$ ), isocyanides ( $-\text{NC}$ ),  
30 nitroso groups ( $-\text{N}=\text{O}$ ), thionitroso groups ( $-\text{N}=\text{S}$ ), nitro groups ( $-\text{NO}_2$ ), azido groups ( $-\text{N}_3$ ), cyanamide or cyanonitrene groups ( $=\text{N}-\text{CN}$ ), cyanate groups ( $-\text{O}-\text{CN}$ ), isocyanate groups ( $-\text{N}=\text{C}=\text{O}$ ), or combinations thereof.

N=C=O), thiocyanate groups (-S-CN), isothiocyanate groups (-N=C=S), nitrosamine groups (=N-N=O), thionitrosamine groups (=N-N=S), nitramine groups (=N-NO<sub>2</sub>), thionitramine groups (=N-NS<sub>2</sub>), carbonylnitrene groups (-CO-N), thiocarbonylnitrene groups (-CS-N), sulfenyl halides (-S-X), sulfoxides (=S=O), sulfones (=S[=O]<sub>2</sub>), sulfinyl groups (-N=S=O), thiosulfinyl groups (-N=S=S), sulfenyl thiocyanato groups (-S-S-CN), sulfenyl cyanato groups (-S-O-CN), sulfodiimine groups (=S[=NH]<sub>2</sub>), sulfur dihaloimido groups (-N=SX<sub>2</sub>), sulfur oxide dihaloimido groups (-N=S[=O]X<sub>2</sub>), aminosulfur oxide trihalide groups (=N-S[=O]X<sub>3</sub>), sulfonyl azide groups (-S[=O]<sub>2</sub>N<sub>3</sub>), sulfonyl thiocyanate groups (-S[=O]<sub>2</sub>SCN), sulfonyl cyanate groups (-S[=O]<sub>2</sub>OCN), sulfonyl cyanide groups (-S[=O]<sub>2</sub>CN), halosulfonate groups (-S[=O]<sub>2</sub>OX), phosphonyl thiocyanate groups (-P[=O]OHSCN), phosphonyl cyanate groups (-P[=O]OHOCN), phosphonyl cyanide groups (-P[=O]OHCN), or combinations thereof.

37. The conversion coating of claim 1 further comprising a solubility control agent.

38. The conversion coating of claim 37 wherein the solubility control agent is a cationic solubility control agent or an anionic solubility control agent.

39. The conversion coating of claim 38 wherein the solubility control agent is the cationic solubility control agent selected from H<sup>+</sup>; Li<sup>+</sup>; Na<sup>+</sup>; K<sup>+</sup>; Rb<sup>+</sup>; Cs<sup>+</sup>; NH<sub>4</sub><sup>+</sup>; Mg<sup>+2</sup>; Ca<sup>+2</sup>; Sr<sup>+2</sup>; Be<sup>+2</sup>; Ba<sup>+2</sup>; Y<sup>+3</sup>; La<sup>+3</sup>; Ce<sup>+3</sup>; Ce<sup>+4</sup>; Nd<sup>+3</sup>; Pr<sup>+3</sup>; Sc<sup>+3</sup>; Sm<sup>+3</sup>; Eu<sup>+3</sup>; Eu<sup>+2</sup>; Gd<sup>+3</sup>; Tb<sup>+3</sup>; Dy<sup>+3</sup>; Ho<sup>+3</sup>; Er<sup>+3</sup>; Tm<sup>+3</sup>; Yb<sup>+3</sup>; Lu<sup>+3</sup>; Ti<sup>+4</sup>; Zr<sup>+4</sup>; Ti<sup>+3</sup>; Hf<sup>+4</sup>; Nb<sup>+5</sup>; Ta<sup>+5</sup>; Nb<sup>+4</sup>; Ta<sup>+4</sup>; V<sup>+5</sup>; V<sup>+4</sup>; V<sup>+3</sup>; Mo<sup>+6</sup>; W<sup>+6</sup>; Mo<sup>+5</sup>; W<sup>+5</sup>; Mo<sup>+4</sup>; W<sup>+4</sup>; Cr<sup>+3</sup>; Mn<sup>+2</sup>; Mn<sup>+3</sup>; Mn<sup>+4</sup>; Fe<sup>+2</sup>; Fe<sup>+3</sup>; Co<sup>+2</sup>; Co<sup>+3</sup>; Ni<sup>+2</sup>; Ni<sup>+3</sup>; Ni<sup>+4</sup>; Ru<sup>+2</sup>; Ru<sup>+3</sup>; Ru<sup>+4</sup>; Rh<sup>+3</sup>; Ir<sup>+3</sup>; Rh<sup>+2</sup>; Ir<sup>+2</sup>; Pd<sup>+4</sup>; Pt<sup>+4</sup>; Pd<sup>+2</sup>; Pt<sup>+2</sup>; Os<sup>+4</sup>; Cu<sup>+</sup>; Cu<sup>+2</sup>; Cu<sup>+3</sup>; Ag<sup>+</sup>; Ag<sup>+2</sup>; Ag<sup>+3</sup>; Au<sup>+</sup>; Au<sup>+2</sup>; Au<sup>+3</sup>; Zn<sup>+2</sup>; Cd<sup>+2</sup>; Hg<sup>+</sup>; Hg<sup>+2</sup>; Al<sup>+3</sup>; Ga<sup>+3</sup>; Ga<sup>+</sup>; In<sup>+3</sup>; In<sup>+</sup>; Tl<sup>+3</sup>; Tl<sup>+</sup>; Ge<sup>+4</sup>; Ge<sup>+2</sup>; Sn<sup>+4</sup>; Sn<sup>+2</sup>; Pb<sup>+4</sup>; Pb<sup>+2</sup>; Sb<sup>+3</sup>; Sb<sup>+5</sup>; As<sup>+3</sup>; As<sup>+5</sup>; Bi<sup>+3</sup>; Bi<sup>+5</sup>; organic compounds containing at least one N<sup>+</sup> site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; quaternary ammonium compounds having a formula NR<sub>4</sub><sup>+</sup>, where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

40. The conversion coating of claim 39 wherein the cationic solubility control agent is selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;   
 5  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one iodonium site; quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

41. The conversion coating of claim 38 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates, chlorotitanates, fluorozirconates, chlorozirconates, fluoroniobates, chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates, fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates, chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates, fluoroaluminates, chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates,   
 20 nitrates, nitrites, azides, cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates, thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates, chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates, fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates, iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides,   
 25 cyanocobaltates, cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates, cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates, thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates, cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates, nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates,   
 30 tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates, tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates,

(thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides,  
amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates,  
imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates,  
tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides,  
5 amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates,  
diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates,  
stibonates, cyanides, cyanochromates, cyanonickelates, cyanatochromates, cyanatonickelates,  
thiocyanatochromates, thiocyanatonickelates, cyanamidochromates, cyanamidonickelates,  
nitritonickelates, arsonates, diarsonates, triarsonates, organic selenates, diselenates, triselenates,  
10 arsenates, arsenites, fluoroarsenates, chloroarsenates, selenates, selenites, fluorothallates,  
chlorothallates, iodo mercury anions, chloromercurates, bromomercurates, osmates,  
fluoronickelates, chromates, Reinecke's salt, vanadates, or combinations thereof.

42. The conversion coating of claim 41 wherein the anionic solubility control agent is  
15 selected from fluorotitanates, chlorotitanates, fluoro zirconates, chloro zirconates, fluoroniobates,  
chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates,  
fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates,  
chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates, fluoroaluminates,  
chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates, nitrates, nitrites, azides,  
20 cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates,  
thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates,  
chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates,  
fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates,  
iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides, cyanocobaltates,  
25 cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates,  
cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates,  
thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates,  
cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates,  
nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates,  
30 tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates,  
tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates,

(thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides, amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates, imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates, tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides, amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates, diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates, stibonates, or combinations thereof.

43. The conversion coating of claim 1 wherein the conversion coating is colored.

44. The conversion coating of claim 43 further comprising an agent which improves color-fastness of the conversion coating.

45. The conversion coating of claim 44 wherein the agent which improves color-fastness is selected from an active UV blocker, a passive UV blocker, a brightener, or a combination thereof.

46. The conversion coating of claim 45 wherein the agent which improves color-fastness is the active UV blocker selected from carbon black, graphite, phthalocyanines, or combinations thereof.

47. The conversion coating of claim 45 wherein the agent which improves color-fastness is the passive UV blocker selected from titanium oxide, tin oxide, lead oxide, silicon oxide, silicates, aluminosilicates, or combinations thereof.

48. The conversion coating of claim 45 wherein the agent which improves color-fastness is the brightener selected from sulfonic acids, sulfonates, sulfonamides, sulfinic acids, sulfinates, sulfones, cyanides, nonionic surfactants, or combinations thereof.

49. The conversion coating of claim 43 wherein the color is formed by a dye selected from vat dyes, mordant dyes, lake dyes, disperse dyes, azo dyes, triazene dyes, triphenylmethane dyes,

azine dyes, formazan dyes, phthalocyanine dyes, Schiff Base dyes, naturally-occurring dyes, inorganic pigments, or combinations thereof.

50. A method of making a corrosion-inhibiting conversion coating bath comprising:

5 providing a solvent;

providing a rare earth source wherein

the rare earth source is selected from a cerium source, a praseodymium source, a terbium source, or a combination thereof, and

at least one rare earth source is in the tetravalent oxidation state;

10 providing a valence stabilizer; and

combining the rare earth source and the valence stabilizer to form a rare earth/valence stabilizer complex.

51. The method of claim 50 wherein the solvent comprises water.

52. The method of claim 50 wherein

the cerium source is selected from a trivalent cerium source, a tetravalent cerium source, or a combination thereof;

the praseodymium source is selected from a trivalent praseodymium source, a tetravalent praseodymium source, or a combination thereof; and

the terbium source is selected from a trivalent terbium source, a tetravalent terbium source, or a combination thereof.

53. The method of claim 50 further comprising oxidizing the rare earth source to form the at least one rare earth source in the tetravalent oxidation state.

54. The method of claim 53 wherein the rare earth source is oxidized by adding an oxidizer to the conversion coating bath.

55. The method of claim 54 wherein the oxidizer is a dissolved solid, a liquid, or a gas.

56. The method of claim 54 wherein the oxidizer is selected from peroxides, superoxides, persulfates, perborates, pernitrates, perphosphates, percarbonates, persilicates, peraluminates, pertitanates, perzirconates, permolybdates, pertungstates, pervanadates, organic peroxyacid derivatives, ozone, hypochlorites, chlorates, perchlorates, nitrates, nitrites, vanadates, iodates, hypobromites, chlorites, bromates, permanganates, periodates, dissolved oxygen, dissolved chlorine, dissolved fluorine, or combinations thereof.

57. The method of claim 53 wherein the rare earth source is oxidized by electrolysis.

58. The method of claim 50 wherein the cerium source is selected from cerium contained within a treated substrate, cerium (III) nitrate, cerium (III) sulfate, cerium (III) perchlorate, cerium (III) chloride, cerium (III) fluoride, cerium (III) bromide, cerium (III) iodide, cerium (III) bromate, cerium (III) fluosilicate, cerium (III) fluotitanate, cerium (III) fluozirconate, cerium (III) fluoborate, cerium (III) fluoaluminate, cerium (III) formate, cerium (III) acetate, cerium (III) propionate, cerium (III) butyrate, cerium (III) glycolate, cerium (III) lactate, cerium (III) sulfonate, cerium (III) alkyl sulfonate, cerium (III) alkoxysulfonate, cerium (III) aromatic sulfonate, cerium (III) aromatoxy sulfonate, cerium (III) sulfamate, cerium (III) alkyl phosphates, cerium (III) acetylacetonate, ammonium cerium (III) sulfate, ammonium cerium (III) nitrate, ammonium cerium (III) oxalate, magnesium cerium (III) sulfate, magnesium cerium (III) nitrate, alkali metal cerium (III) nitrate, alkali metal cerium (III) sulfate, cerium (III) carbonate, cerium (III) phosphate, cerium (III) sulfide, cerium (III) fluorocarbonate, cerium (III) benzoate, cerium (III) oxalate, cerium (III) malonate, cerium (III) tartrate, cerium (III) malate, cerium (III) citrate, cerium (III) thiocyanate, cerium (III) salicylate, cerium (III) oxide, cerium (III) hydroxide, cerium (IV) hydroxide species with a hydroxide content of less than or about 50%, cerium (IV) hydroxysulfate, cerium (IV) hydroxychloride, cerium (IV) hydroxynitrate, cerium (IV) hydroxyphosphate, cerium (IV) hydroxyperchlorate, cerium (IV) hydroxyacetate, cerium (IV) chloride, cerium (IV) fluoride, cerium (IV) perchlorate, cerium (IV) sulfate, cerium (IV) nitrate, cerium (IV) acetate, cerium (IV) propionate, cerium (IV) butyrate, ammonium cerium (IV) nitrate, ammonium cerium (IV) sulfate, magnesium cerium (IV) nitrate, magnesium cerium (IV) sulfate, alkali metal cerium (IV) nitrate, alkali metal cerium (IV) sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, ceibaite, aeschynite, lucasite,



stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

59. The method of claim 50 wherein the praseodymium source is selected from  
5 praseodymium contained within a treated substrate, praseodymium nitrate, praseodymium  
sulfate, praseodymium perchlorate, praseodymium chloride, praseodymium fluoride,  
praseodymium bromide, praseodymium iodide, praseodymium bromate, praseodymium  
fluosilicate, praseodymium fluotitanate, praseodymium fluozirconate, praseodymium fluoborate,  
praseodymium fluoaluminate, praseodymium formate, praseodymium acetate, praseodymium  
10 propionate, praseodymium lactate, praseodymium benzenesulfonate, praseodymium  
acetylacetonate, ammonium praseodymium sulfate, ammonium praseodymium nitrate,  
magnesium praseodymium sulfate, magnesium praseodymium nitrate, alkali metal  
praseodymium nitrate, alkali metal praseodymium sulfate, bastnaesite, monazite, xenotime,  
loparite, lanthanite, rhabdophane, fergusonite, cebaite, aeschynite, lucasite, stillwellite,  
15 samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

60. The method of claim 50 wherein the terbium source is selected from terbium contained  
within a treated substrate, terbium nitrate, terbium sulfate, terbium perchlorate, terbium chloride,  
terbium fluoride, terbium bromide, terbium iodide, terbium bromate, terbium fluosilicate,  
20 terbium fluotitanate, terbium fluozirconate, terbium fluoborate, terbium fluoaluminate, terbium  
formate, terbium acetate, terbium propionate, terbium lactate, terbium benzenesulfonate, terbium  
acetylacetonate, ammonium terbium sulfate, ammonium terbium nitrate, magnesium terbium  
sulfate, magnesium terbium nitrate, alkali metal terbium nitrate, alkali metal terbium sulfate,  
bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, cebaite,  
25 aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite,  
or combinations thereof.

61. The method of claim 50 wherein the valence stabilizer is selected from an inorganic  
valence stabilizer and an organic valence stabilizer.

62. The method of claim 50 further comprising adding a preparative agent to the conversion coating bath.

63. The method of claim 62 wherein the preparative agent is selected from fluorides,  
5 chlorides, bromides, acidic species, hydroxides, or combinations thereof.

64. The method of claim 63 wherein the preparative agent is a fluoride.

65. The method of claim 64 wherein the fluoride is selected from fluorozeirconates,  
10 fluorotitanates, fluorosilicates, fluoroaluminates, fluoroborates, fluorogallates, fluoroindates,  
fluorogermanates, fluorostannates, fluorophosphates, fluoroarsenates, fluoroantimonates,  
fluorobismuthates, fluorosulfates, fluoroselenates, fluorotellurates, fluorocuprates,  
fluoroargentates, fluorozincates, fluorohafnates, fluorovanadates, fluoroniobates,  
fluorotantalates, fluoromolybdates, fluorotungstates, fluoroyttrates, fluorolanthanates,  
15 fluorocerates, fluoromanganates, fluoroferrates, fluoronickelates, fluorocobaltates, potassium  
fluoride, potassium hydrogen fluoride, sodium fluoride, sodium hydrogen fluoride, lithium  
fluoride, lithium hydrogen fluoride, ammonium fluoride, ammonium hydrogen fluoride,  
hydrofluoric acid, dissolved fluorine, organic fluorides, or combinations thereof.

20 66. The method of claim 63 wherein the preparative agent is an acidic species.

67. The method of claim 66 wherein the acidic species is selected from nitric acid, sulfuric  
acid, phosphoric acid, pyrophosphoric acid, hydrochloric acid, perchloric acid, hydrobromic  
acid, hydriodic acid, iodic acid, periodic acid, disulfuric acid, selenic acid, telluric acid,  
25 polyphosphoric acid, cyclophosphoric acid, phytic acid, boric acid, carboxylic acid, phosphonic  
acid, sulfonic acid, and acidic metal salts of titanium, zirconium, niobium, tantalum,  
molybdenum, tungsten, vanadium, aluminum, silicon, tin, antimony, bismuth, tellurium, yttrium,  
lanthanum, or combinations thereof.

30 68. The method of claim 50 further comprising providing a solubility control agent.

69. The method of claim 68 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

70. The method of claim 69 wherein the solubility control agent is the cationic solubility control agent selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Be^{+2}$ ;  $Ba^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $V^{+5}$ ;  $V^{+4}$ ;  $V^{+3}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Cr^{+3}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ni^{+2}$ ;  $Ni^{+3}$ ;  $Ni^{+4}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Os^{+4}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Cd^{+2}$ ;  $Hg^+$ ;  $Hg^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Tl^{+3}$ ;  $Tl^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Pb^{+4}$ ;  $Pb^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $As^{+3}$ ;  $As^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

71. The method of claim 70 wherein the cationic solubility control agent is selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one iodonium site; quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

72. The method of claim 69 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates, chlorotitanates, fluorozirconates, chlorozirconates, fluoroniobates, chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates, fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates, chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates, fluoroaluminates, chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates, nitrates, nitrites, azides, cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates, thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates, chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates, fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates, iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides, cyanocobaltates, cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates, cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates, thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates, cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates, nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates, tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates, tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates, (thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides, amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates, imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates, tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides, amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates, diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates, stibonates, cyanides, cyanochromates, cyanonickelates, cyanatochromates, cyanatonickelates, thiocyanatochromates, thiocyanatonickelates, cyanamidochromates, cyanamidonickelates, nitritonickelates, arsonates, diarsonates, triarsonates, organic selenates, diselenates, triselenates, arsenates, arsenites, fluoroarsenates, chloroarsenates, selenates, selenites, fluorothallates, chlorothallates, iodoamalgams, chloromercurates, bromomercurates, osmates, fluoronickelates, chromates, Reinecke's salt, vanadates, or combinations thereof.

73. The method of claim 72 wherein the anionic solubility control agent is selected from fluorotitanates, chlorotitanates, fluorozeirconates, chlorozeirconates, fluoroniobates, chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates, fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates, chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates, fluoroaluminates, chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates, nitrates, nitrites, azides, cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates, thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates, chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates, fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates, iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides, cyanocobaltates, cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates, cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates, thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates, cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates, nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates, tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates, tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates, (thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides, amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates, imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates, tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides, amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates, diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates, stibonates, or combinations thereof.

74. The method of claim 50 wherein the conversion coating bath has a concentration of cerium, praseodymium, or terbium of between a minimum concentration of about  $1 \times 10^{-4}$  moles/liter cerium, praseodymium, or terbium and a maximum concentration which is a maximum solubility of the cerium, praseodymium, or terbium source in the solvent at a temperature of the conversion coating bath.

75. The method of claim 54 wherein the conversion coating bath has a concentration of oxidizer of between a minimum concentration wherein a majority of the cerium, praseodymium, or terbium is oxidized to a tetravalent oxidation state and a maximum concentration which is a maximum solubility of the oxidizer in the solvent at a temperature of the conversion coating bath.

76. The method of claim 64 wherein the conversion coating bath has a concentration of preparative agent between a minimum concentration, wherein there is a fluoride-to-cerium, fluoride-to-praseodymium, or fluoride-to-terbium ratio of 0.05 and a maximum concentration, which is a maximum solubility of the preparative agent in the solvent at a temperature of the conversion coating bath.

77. The method of claim 66 wherein the conversion coating bath has a concentration of preparative agent between a minimum concentration, wherein there is an acidic species-to-cerium, acidic species-to-praseodymium, or acidic species-to-terbium ratio of 0.05 and a maximum concentration, which is a maximum solubility of the preparative agent in the solvent at a temperature of the conversion coating bath.

78. The method of claim 50 wherein the conversion coating bath has a concentration of valence stabilizer between a minimum concentration wherein there is a valence stabilizer-to-cerium, valence stabilizer-to-praseodymium, or valence stabilizer-to-terbium ratio of 0.010 and a maximum concentration which is a maximum solubility of the valence stabilizer in the solvent at a temperature of the conversion coating bath.

79. The method of claim 50 wherein the conversion coating bath has a pH of between about -1.5 and about 7.

80. The method of claim 79 wherein the conversion coating bath has a pH of between about 1 and about 6.

81. The method of claim 50 wherein the conversion coating bath has a temperature of between about 5°C and about 100°C.

82. The method of claim 81 wherein the conversion coating bath has a temperature of between about 5°C and about 40°C.

83. A method of applying a corrosion-inhibiting conversion coating, comprising:  
providing a substrate to be coated;  
contacting the substrate with a first conversion coating bath comprising a first solvent and  
a rare earth source wherein  
the rare earth source is selected from a cerium source, a praseodymium  
source, a terbium source, or a combination thereof, and  
at least one rare earth source is in the tetravalent oxidation state; and  
contacting the substrate with a valence stabilizer to form a coating comprising a rare  
earth/valence stabilizer complex.

84. The method of claim 83 wherein the substrate is a metal.

85. The method of claim 84 wherein the metal is selected from magnesium, aluminum, zinc, iron, titanium, cadmium, silver, copper, tin, lead, rare earths, zirconium, beryllium, niobium, tantalum, lithium, indium, and alloys thereof, or combinations thereof.

86. The method of claim 83 wherein the substrate is a metal with a metal coating.

87. The method of claim 86 wherein the metal coating is selected from magnesium, aluminum, zinc, iron, titanium, cadmium, silver, copper, tin, lead, rare earths, zirconium, beryllium, niobium, tantalum, lithium, indium, and alloys thereof, or combinations thereof.

88. The method of claim 83 wherein the first solvent comprises water.

89. The method of claim 83 wherein

the cerium source is selected from a trivalent cerium source, a tetravalent cerium source, or a combination thereof,

the praseodymium source is selected from a trivalent praseodymium source, a tetravalent praseodymium source, or a combination thereof, and

the terbium source is selected from a trivalent terbium source, a tetravalent terbium source, or a combination thereof.

90. The method of claim 83 further comprising oxidizing the rare earth source to form the at least one rare earth source in the tetravalent oxidation state.

91. The method of claim 90 wherein the rare earth source is oxidized in the first conversion coating bath.

92. The method of claim 83 wherein the rare earth source is oxidized in the coating.

93. The method of claim 90 wherein the rare earth source is oxidized by adding an oxidizer to the first conversion coating bath.

94. The method of claim 93 wherein the oxidizer is selected from a dissolved solid, a liquid, and a gas.

95. The method of claim 93 wherein the oxidizer is selected from peroxides, superoxides, persulfates, perborates, pernitrates, perphosphates, percarbonates, persilicates, peraluminates, pertitanates, perzirconates, permolybdates, pertungstates, pervanadates, organic peroxyacid derivatives, ozone, hypochlorites, chlorates, perchlorates, nitrates, nitrites, vanadates, iodates, hypobromites, chlorites, bromates, permanganates, periodates, dissolved oxygen, dissolved chlorine, dissolved fluorine, or combinations thereof.

96. The method of claim 90 wherein the rare earth source is oxidized by electrolysis.



97. The method of claim 83 wherein the cerium source is selected from cerium contained within a treated substrate, cerium (III) nitrate, cerium (III) sulfate, cerium (III) perchlorate, cerium (III) chloride, cerium (III) fluoride, cerium (III) bromide, cerium (III) iodide, cerium (III) bromate, cerium (III) fluosilicate, cerium (III) fluotitanate, cerium (III) fluozirconate, cerium (III) fluoborate, cerium (III) fluoaluminate, cerium (III) formate, cerium (III) acetate, cerium (III) propionate, cerium (III) butyrate, cerium (III) glycolate, cerium (III) lactate, cerium (III) sulfonate, cerium (III) alkyl sulfonate, cerium (III) alkoxysulfonate, cerium (III) aromatic sulfonate, cerium (III) aromatoxy sulfonate, cerium (III) sulfamate, cerium (III) alkyl phosphates, cerium (III) acetylacetonate, ammonium cerium (III) sulfate, ammonium cerium (III) nitrate, ammonium cerium (III) oxalate, magnesium cerium (III) sulfate, magnesium cerium (III) nitrate, alkali metal cerium (III) nitrate, alkali metal cerium (III) sulfate, cerium (III) carbonate, cerium (III) phosphate, cerium (III) sulfide, cerium (III) fluorocarbonate, cerium (III) benzoate, cerium (III) oxalate, cerium (III) malonate, cerium (III) tartrate, cerium (III) malate, cerium (III) citrate, cerium (III) thiocyanate, cerium (III) salicylate, cerium (III) oxide, cerium (III) hydroxide, cerium (IV) hydroxide species with a hydroxide content of less than or about 50%, cerium (IV) hydroxysulfate, cerium (IV) hydroxychloride, cerium (IV) hydroxynitrate, cerium (IV) hydroxyphosphate, cerium (IV) hydroxyperchlorate, cerium (IV) hydroxyacetate, cerium (IV) chloride, cerium (IV) fluoride, cerium (IV) perchlorate, cerium (IV) sulfate, cerium (IV) nitrate, cerium (IV) acetate, cerium (IV) propionate, cerium (IV) butyrate, ammonium cerium (IV) nitrate, ammonium cerium (IV) sulfate, magnesium cerium (IV) nitrate, magnesium cerium (IV) sulfate, alkali metal cerium (IV) nitrate, alkali metal cerium (IV) sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, ceibaite, aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

98. The method of claim 83 wherein the praseodymium source is selected from praseodymium contained within a treated substrate, praseodymium nitrate, praseodymium sulfate, praseodymium perchlorate, praseodymium chloride, praseodymium fluoride, praseodymium bromide, praseodymium iodide, praseodymium bromate, praseodymium fluosilicate, praseodymium fluotitanate, praseodymium fluozirconate, praseodymium fluoborate, praseodymium fluoaluminate, praseodymium formate, praseodymium acetate, praseodymium

propionate, praseodymium lactate, praseodymium benzenesulfonate, praseodymium acetylacetonate, ammonium praseodymium sulfate, ammonium praseodymium nitrate, magnesium praseodymium sulfate, magnesium praseodymium nitrate, alkali metal praseodymium nitrate, alkali metal praseodymium sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, cebaite, aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

99. The method of claim 83 wherein the terbium source is selected from terbium contained within a treated substrate, terbium nitrate, terbium sulfate, terbium perchlorate, terbium chloride, terbium fluoride, terbium bromide, terbium iodide, terbium bromate, terbium fluosilicate, terbium fluotitanate, terbium fluozirconate, terbium fluoborate, terbium fluoaluminate, terbium formate, terbium acetate, terbium propionate, terbium lactate, terbium benzenesulfonate, terbium acetylacetonate, ammonium terbium sulfate, ammonium terbium nitrate, magnesium terbium sulfate, magnesium terbium nitrate, alkali metal terbium nitrate, alkali metal terbium sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, cebaite, aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

100. The method of claim 83 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

101. The method of claim 83 wherein the valence stabilizer is added to the first conversion coating bath.

102. The method of claim 83 further comprising providing a second conversion coating bath comprising a second solvent and the valence stabilizer.

103. The method of claim 102 wherein the second solvent comprises water.

104. The method of claim 83 wherein the substrate is contacted with the first conversion coating bath by a process selected from immersion, spraying, fogging, wiping, and dipping.

105. The method of claim 102 wherein the substrate is contacted with the second conversion coating bath by a process selected from immersion, spraying, fogging, wiping, and dipping.

106. The method of claim 83 further comprising adding a preparative agent to the first conversion coating bath.

107. The method of claim 106 wherein the preparative agent is selected from fluorides, chlorides, bromides, acidic species, hydroxides, or combinations thereof.

108. The method of claim 107 wherein the preparative agent is a fluoride.

109. The method of claim 108 wherein the fluoride is selected from fluorozirconates, fluorotitanates, fluorosilicates, fluoroaluminates, fluoroborates, fluorogallates, fluoroindates, fluorogermanates, fluorostannates, fluorophosphates, fluoroarsenates, fluoroantimonates, fluorobismuthates, fluorosulfates, fluoroselenates, fluorotellurates, fluorocuprates, fluoroargentates, fluorozincates, fluoro hafnates, fluoro vanadates, fluoroniobates, fluorotantalates, fluoromolybdates, fluorotungstates, fluoroyttrates, fluorolanthanates, fluorocerates, fluoromanganates, fluoroferrates, fluoronickelates, fluorocobaltates, potassium fluoride, potassium hydrogen fluoride, sodium fluoride, sodium hydrogen fluoride, lithium fluoride, lithium hydrogen fluoride, ammonium fluoride, ammonium hydrogen fluoride, hydrofluoric acid, dissolved fluorine, organic fluorides, or combinations thereof.

110. The method of claim 107 wherein the preparative agent is an acidic species.

111. The method of claim 110 wherein the acidic species is selected from nitric acid, sulfuric acid, phosphoric acid, pyrophosphoric acid, hydrochloric acid, perchloric acid, hydrobromic acid, hydriodic acid, iodic acid, periodic acid, disulfuric acid, selenic acid, telluric acid, polyphosphoric acid, cyclophosphoric acid, phytic acid, boric acid, carboxylic acid, phosphonic acid, sulfonic acid, and acidic metal salts of titanium, zirconium, niobium, tantalum, molybdenum, tungsten, vanadium, aluminum, silicon, tin, antimony, bismuth, tellurium, yttrium, lanthanum, or combinations thereof.

112. The method of claim 83 further comprising contacting the coating comprising the rare earth/valence stabilizer complex with a solubility control agent.

113. The method of claim 112 wherein the solubility control agent is added to the first conversion coating bath.

114. The method of claim 112 further comprising a second conversion coating bath comprising a second solvent, the valence stabilizer, and the solubility control agent.

115. The method of claim 114 wherein the second solvent is water.

116. The method of claim 112 further comprising a third conversion coating bath comprising the solubility control agent and a third solvent.

117. The method of claim 116 wherein the third solvent is water.

118. The method of claim 112 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

119. The method of claim 118 wherein the solubility control agent is the cationic solubility control agent selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Be^{+2}$ ;  $Ba^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $V^{+5}$ ;  $V^{+4}$ ;  $V^{+3}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Cr^{+3}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ni^{+2}$ ;  $Ni^{+3}$ ;  $Ni^{+4}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Os^{+4}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Cd^{+2}$ ;  $Hg^+$ ;  $Hg^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Tl^{+3}$ ;  $Tl^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Pb^{+4}$ ;  $Pb^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $As^{+3}$ ;  $As^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at

least one iodonium site; quaternary ammonium compounds having a formula  $\text{NR}_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

120. The method of claim 119 wherein the cationic solubility control agent is selected from  
5  $\text{H}^+$ ;  $\text{Li}^+$ ;  $\text{Na}^+$ ;  $\text{K}^+$ ;  $\text{Rb}^+$ ;  $\text{Cs}^+$ ;  $\text{NH}_4^+$ ;  $\text{Mg}^{+2}$ ;  $\text{Ca}^{+2}$ ;  $\text{Sr}^{+2}$ ;  $\text{Y}^{+3}$ ;  $\text{La}^{+3}$ ;  $\text{Ce}^{+3}$ ;  $\text{Ce}^{+4}$ ;  $\text{Nd}^{+3}$ ;  $\text{Pr}^{+3}$ ;  $\text{Sc}^{+3}$ ;  
 $\text{Sm}^{+3}$ ;  $\text{Eu}^{+3}$ ;  $\text{Eu}^{+2}$ ;  $\text{Gd}^{+3}$ ;  $\text{Tb}^{+3}$ ;  $\text{Dy}^{+3}$ ;  $\text{Ho}^{+3}$ ;  $\text{Er}^{+3}$ ;  $\text{Tm}^{+3}$ ;  $\text{Yb}^{+3}$ ;  $\text{Lu}^{+3}$ ;  $\text{Ti}^{+4}$ ;  $\text{Zr}^{+4}$ ;  $\text{Ti}^{+3}$ ;  $\text{Hf}^{+4}$ ;  $\text{Nb}^{+5}$ ;  
 $\text{Ta}^{+5}$ ;  $\text{Nb}^{+4}$ ;  $\text{Ta}^{+4}$ ;  $\text{Mo}^{+6}$ ;  $\text{W}^{+6}$ ;  $\text{Mo}^{+5}$ ;  $\text{W}^{+5}$ ;  $\text{Mo}^{+4}$ ;  $\text{W}^{+4}$ ;  $\text{Mn}^{+2}$ ;  $\text{Mn}^{+3}$ ;  $\text{Mn}^{+4}$ ;  $\text{Fe}^{+2}$ ;  $\text{Fe}^{+3}$ ;  $\text{Co}^{+2}$ ;  $\text{Co}^{+3}$ ;  
 $\text{Ru}^{+2}$ ;  $\text{Ru}^{+3}$ ;  $\text{Ru}^{+4}$ ;  $\text{Rh}^{+3}$ ;  $\text{Ir}^{+3}$ ;  $\text{Rh}^{+2}$ ;  $\text{Ir}^{+2}$ ;  $\text{Pd}^{+4}$ ;  $\text{Pt}^{+4}$ ;  $\text{Pd}^{+2}$ ;  $\text{Pt}^{+2}$ ;  $\text{Cu}^{+}$ ;  $\text{Cu}^{+2}$ ;  $\text{Cu}^{+3}$ ;  $\text{Ag}^{+}$ ;  $\text{Ag}^{+2}$ ;  $\text{Ag}^{+3}$ ;  
 $\text{Au}^{+}$ ;  $\text{Au}^{+2}$ ;  $\text{Au}^{+3}$ ;  $\text{Zn}^{+2}$ ;  $\text{Al}^{+3}$ ;  $\text{Ga}^{+3}$ ;  $\text{Ga}^{+}$ ;  $\text{In}^{+3}$ ;  $\text{In}^{+}$ ;  $\text{Ge}^{+4}$ ;  $\text{Ge}^{+2}$ ;  $\text{Sn}^{+4}$ ;  $\text{Sn}^{+2}$ ;  $\text{Sb}^{+3}$ ;  $\text{Sb}^{+5}$ ;  $\text{Bi}^{+3}$ ;  $\text{Bi}^{+5}$ ;  
10 organic compounds containing at least one  $\text{N}^+$  site; organic compounds containing at least one  
phosphonium site; organic compounds containing at least one stibonium site; organic compounds  
containing at least one oxonium site; organic compounds containing at least one sulfonium site;  
organic compounds containing at least one iodonium site; quaternary ammonium compounds  
having a formula  $\text{NR}_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or  
15 combinations thereof.

121. The method of claim 118 wherein the solubility control agent is the anionic solubility  
control agent selected from fluorotitanates, chlorotitanates, fluorozirconates, chlorozirconates,  
fluoroniobates, chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates,  
20 permanganates, fluoromanganates, chloromanganates, fluoroferrates, chloroferrates,  
fluorocobaltates, chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates,  
fluoroaluminates, chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates,  
nitrates, nitrites, azides, cyanamides, phosphates, phosphites, phosphonates, phosphinites,  
thiophosphates, thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates,  
25 fluoroantimonates, chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites,  
dithionates, fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides,  
bromates, iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides,  
cyanocobaltates, cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates,  
cyanatocuprates, cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates,  
30 thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates,  
cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates,

nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates, tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates, tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates, (thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides, amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates, imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates, tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides, amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates, diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates, stibonates, cyanides, cyanochromates, cyanonickelates, cyanatochromates, cyanatonickelates, thiocyanatochromates, thiocyanatonickelates, cyanamidochromates, cyanamidonickelates, nitritonickelates, arsonates, diarsonates, triarsonates, organic selenates, diselenates, triselenates, arsenates, arsenites, fluoroarsenates, chloroarsenates, selenates, selenites, fluorothallates, chlorothallates, iodo mercury anions, chloromercurates, bromomercurates, osmates, fluoronickelates, chromates, Reinecke's salt, vanadates, or combinations thereof.

122. The method of claim 121 wherein the anionic solubility control agent is selected from fluorotitanates, chlorotitanates, fluoro zirconates, chlorozirconates, fluoroniobates, chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates, fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates, chlorocobaltates, fluoro zincates, chlorozincates, borates, fluoroborates, fluoroaluminates, chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates, nitrates, nitrites, azides, cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates, thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates, chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates, fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates, iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides, cyanocobaltates, cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates, cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates, thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates, cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates,

nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates, tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates, tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates, (thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides, amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates, imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates, tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides, amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates, diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates, stibonates, or combinations thereof.

123. The method of claim 83 wherein the first conversion coating bath has a concentration of cerium, praseodymium, or terbium of between a minimum concentration of about  $1 \times 10^{-4}$  moles/liter cerium, praseodymium, or terbium and a maximum concentration which is a maximum solubility of the cerium, praseodymium, or terbium source in the first solvent at a temperature of the conversion coating bath.

124. The method of claim 93 wherein the first conversion coating bath has a concentration of oxidizer of between a minimum concentration wherein a majority of the cerium, praseodymium, or terbium is oxidized to a tetravalent oxidation state and a maximum concentration which is a maximum solubility of the oxidizer in the first solvent at a temperature of the first conversion coating bath.

125. The method of claim 108 wherein the first conversion coating bath has a concentration of preparative agent between a minimum concentration, wherein there is a fluoride-to-cerium, fluoride-to-praseodymium, or fluoride-to-terbium ratio of 0.05 and a maximum concentration, which is a maximum solubility of the preparative agent in the first solvent at a temperature of the first conversion coating bath.

126. The method of claim 110 wherein the first conversion coating bath has a concentration of preparative agent between a minimum concentration, wherein there is an acidic species-to-

cerium, acidic species-to-praseodymium, or acidic species-to-terbium ratio of 0.05 and a maximum concentration, which is a maximum solubility of the preparative agent in the first solvent at a temperature of the first conversion coating bath.

5        127.    The method of claim 83 wherein the first conversion coating bath has a concentration of valence stabilizer between a minimum concentration wherein there is a valence stabilizer-to-cerium, valence stabilizer-to-praseodymium, or valence stabilizer-to-terbium ratio of 0.010 and a maximum concentration which is a maximum solubility of the valence stabilizer in the first solvent at a temperature of the first conversion coating bath.

10        128.    The method of claim 83 wherein the first conversion coating bath has a pH of between about -1.5 and 7.

15        129.    The method of claim 128 wherein the first conversion coating bath has a pH of between about 1 and about 6.

130.    The method of claim 83 wherein the first conversion coating bath has a temperature of between about 5°C and about 100°C.

20        131.    The method of claim 130 wherein the first conversion coating bath has a temperature of between about 5°C and about 40°C.

132.    A corrosion-inhibiting conversion coating bath comprising  
a solvent;  
25        a rare earth source wherein  
          the rare earth source is selected from a cerium source, a praseodymium source, a terbium source, or a combination thereof, and  
          at least one rare earth source is in the tetravalent oxidation state; and  
          a valence stabilizer combined to form a rare earth/valence stabilizer complex.

30        133.    The conversion coating bath of claim 132 wherein the solvent is water.



134. The conversion coating bath of claim 132 wherein

the cerium source is selected from a trivalent cerium source, a tetravalent cerium source, or a combination thereof;

the praseodymium source is selected from a trivalent cerium source, a tetravalent cerium source, or a combination thereof; and

the terbium source is selected from a trivalent terbium source, a tetravalent terbium source, or a combination thereof.

135. The conversion coating bath of claim 132 further comprising an oxidizer to form the at least one rare earth source in the tetravalent oxidation state.

136. The conversion coating bath of claim 135 wherein the oxidizer is selected from a dissolved solid, a liquid, or a gas.

137. The conversion coating bath of claim 136 wherein the oxidizer is selected from peroxides, superoxides, persulfates, perborates, pernitrates, perphosphates, percarbonates, persilicates, peraluminates, pertitanates, perzirconates, permolybdates, pertungstates, pervanadates, organic peroxyacid derivatives, ozone, hypochlorites, chlorates, perchlorates, nitrates, nitrites, vanadates, iodates, hypobromites, chlorites, bromates, permanganates, periodates, dissolved oxygen, dissolved chlorine, dissolved fluorine, or combinations thereof.

138. The conversion coating bath of claim 132 wherein the cerium source is selected from cerium contained within a treated substrate, cerium (III) nitrate, cerium (III) sulfate, cerium (III) perchlorate, cerium (III) chloride, cerium (III) fluoride, cerium (III) bromide, cerium (III) iodide, cerium (III) bromate, cerium (III) fluosilicate, cerium (III) fluotitanate, cerium (III) fluozirconate, cerium (III) fluoborate, cerium (III) fluoaluminate, cerium (III) formate, cerium (III) acetate, cerium (III) propionate, cerium (III) butyrate, cerium (III) glycolate, cerium (III) lactate, cerium (III) sulfonate, cerium (III) alkyl sulfonate, cerium (III) alkoxysulfonate, cerium (III) aromatic sulfonate, cerium (III) aromatoxy sulfonate, cerium (III) sulfamate, cerium (III) alkyl phosphates, cerium (III) acetylacetonate, ammonium cerium (III) sulfate, ammonium cerium (III) nitrate, ammonium cerium (III) oxalate, magnesium cerium (III) sulfate, magnesium

cerium (III) nitrate, alkali metal cerium (III) nitrate, alkali metal cerium (III) sulfate, cerium (III) carbonate, cerium (III) phosphate, cerium (III) sulfide, cerium (III) fluorocarbonate, cerium (III) benzoate, cerium (III) oxalate, cerium (III) malonate, cerium (III) tartrate, cerium (III) malate, cerium (III) citrate, cerium (III) thiocyanate, cerium (III) salicylate, cerium (III) oxide, cerium (III) hydroxide, cerium (IV) hydroxide species with a hydroxide content of less than or about 50%, cerium (IV) hydroxysulfate, cerium (IV) hydroxychloride, cerium (IV) hydroxynitrate, cerium (IV) hydroxyphosphate, cerium (IV) hydroxyperchlorate, cerium (IV) hydroxyacetate, cerium (IV) chloride, cerium (IV) fluoride, cerium (IV) perchlorate, cerium (IV) sulfate, cerium (IV) nitrate, cerium (IV) acetate, cerium (IV) propionate, cerium (IV) butyrate, ammonium cerium (IV) nitrate, ammonium cerium (IV) sulfate, magnesium cerium (IV) nitrate, magnesium cerium (IV) sulfate, alkali metal cerium (IV) nitrate, alkali metal cerium (IV) sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, cebaite, aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

139. The conversion coating bath of claim 132 wherein the praseodymium source is selected from praseodymium contained within the treated substrate, praseodymium nitrate, praseodymium sulfate, praseodymium perchlorate, praseodymium chloride, praseodymium fluoride, praseodymium bromide, praseodymium iodide, praseodymium bromate, praseodymium fluosilicate, praseodymium fluotitanate, praseodymium fluozirconate, praseodymium fluoborate, praseodymium fluoaluminate, praseodymium formate, praseodymium acetate, praseodymium propionate, praseodymium lactate, praseodymium benzenesulfonate, praseodymium acetylacetonate, ammonium praseodymium sulfate, ammonium praseodymium nitrate, magnesium praseodymium sulfate, magnesium praseodymium nitrate, alkali metal praseodymium nitrate, alkali metal praseodymium sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, cebaite, aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

140. The conversion coating bath of claim 132 wherein the terbium source is selected from terbium contained within the treated substrate, terbium nitrate, terbium sulfate, terbium perchlorate, terbium chloride, terbium fluoride, terbium bromide, terbium iodide, terbium

bromate, terbium fluosilicate, terbium fluotitanate, terbium fluozirconate, terbium fluoborate, terbium fluoaluminate, terbium formate, terbium acetate, terbium propionate, terbium lactate, terbium benzenesulfonate, terbium acetylacetonate, ammonium terbium sulfate, ammonium terbium nitrate, magnesium terbium sulfate, magnesium terbium nitrate, alkali metal terbium nitrate, alkali metal terbium sulfate, bastnaesite, monazite, xenotime, loparite, lanthanite, rhabdophane, fergusonite, cebaite, aeschynite, lucasite, stillwellite, samarskite, parisite, gadolinite, fluocerite, cerianite, churchite, or combinations thereof.

141. The conversion coating bath of claim 132 further comprising a preparative agent.

142. The conversion coating bath of claim 141 wherein the preparative agent is selected from fluorides, chlorides, bromides, acidic species, hydroxides, or combinations thereof.

143. The conversion coating bath of claim 142 wherein the preparative agent is a fluoride.

144. The conversion coating bath of claim 143 wherein the fluoride is selected from fluorozirconates, fluorotitanates, fluorosilicates, fluoroaluminates, fluoroborates, fluorogallates, fluoroindates, fluorogermanates, fluorostannates, fluorophosphates, fluoroarsenates, fluoroantimonates, fluorobismuthates, fluorosulfates, fluoroselenates, fluorotellurates, fluorocuprates, fluoroargentates, fluorozincates, fluorohafnates, fluorovanadates, fluoroniobates, fluorotantalates, fluoromolybdates, fluorotungstates, fluoroyttrates, fluorolanthanates, fluorocerates, fluoromanganates, fluoroferrates, fluoronickelates, fluorocobaltates, potassium fluoride, potassium hydrogen fluoride, sodium fluoride, sodium hydrogen fluoride, lithium fluoride, lithium hydrogen fluoride, ammonium fluoride, ammonium hydrogen fluoride, hydrofluoric acid, dissolved fluorine, organic fluorides, or combinations thereof.

145. The conversion coating bath of claim 142 wherein the preparative agent is an acidic species.

146. The conversion coating bath of claim 145 wherein the acidic species is selected from nitric acid, sulfuric acid, phosphoric acid, pyrophosphoric acid, hydrochloric acid, perchloric

acid, hydrobromic acid, hydriodic acid, iodic acid, periodic acid, disulfuric acid, selenic acid, telluric acid, polyphosphoric acid, cyclophosphoric acid, phytic acid, boric acid, carboxylic acid, phosphonic acid, sulfonic acid, and acidic metal salts of titanium, zirconium, niobium, tantalum, molybdenum, tungsten, vanadium, aluminum, silicon, tin, antimony, bismuth, tellurium, yttrium, lanthanum, or combinations thereof.

147. The conversion coating bath of claim 132 wherein the valence stabilizer is selected from an inorganic valence stabilizer and an organic valence stabilizer.

148. The conversion coating bath of claim 132 further comprising a solubility control agent.

149. The conversion coating bath of claim 148 wherein the solubility control agent is selected from a cationic solubility control agent and an anionic solubility control agent.

150. The conversion coating bath of claim 149 wherein the solubility control agent is the cationic solubility control agent selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Be^{+2}$ ;  $Ba^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $V^{+5}$ ;  $V^{+4}$ ;  $V^{+3}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Cr^{+3}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ni^{+2}$ ;  $Ni^{+3}$ ;  $Ni^{+4}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Os^{+4}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Cd^{+2}$ ;  $Hg^+$ ;  $Hg^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Tl^{+3}$ ;  $Tl^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Pb^{+4}$ ;  $Pb^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $As^{+3}$ ;  $As^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one arsonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one selenonium site; organic compounds containing at least one iodonium site; quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

151. The conversion coating bath of claim 150 wherein the cationic solubility control agent is selected from  $H^+$ ;  $Li^+$ ;  $Na^+$ ;  $K^+$ ;  $Rb^+$ ;  $Cs^+$ ;  $NH_4^+$ ;  $Mg^{+2}$ ;  $Ca^{+2}$ ;  $Sr^{+2}$ ;  $Y^{+3}$ ;  $La^{+3}$ ;  $Ce^{+3}$ ;  $Ce^{+4}$ ;  $Nd^{+3}$ ;  $Pr^{+3}$ ;  $Sc^{+3}$ ;  $Sm^{+3}$ ;  $Eu^{+3}$ ;  $Eu^{+2}$ ;  $Gd^{+3}$ ;  $Tb^{+3}$ ;  $Dy^{+3}$ ;  $Ho^{+3}$ ;  $Er^{+3}$ ;  $Tm^{+3}$ ;  $Yb^{+3}$ ;  $Lu^{+3}$ ;  $Ti^{+4}$ ;  $Zr^{+4}$ ;  $Ti^{+3}$ ;  $Hf^{+4}$ ;  $Nb^{+5}$ ;  $Ta^{+5}$ ;  $Nb^{+4}$ ;  $Ta^{+4}$ ;  $Mo^{+6}$ ;  $W^{+6}$ ;  $Mo^{+5}$ ;  $W^{+5}$ ;  $Mo^{+4}$ ;  $W^{+4}$ ;  $Mn^{+2}$ ;  $Mn^{+3}$ ;  $Mn^{+4}$ ;  $Fe^{+2}$ ;  $Fe^{+3}$ ;  $Co^{+2}$ ;  $Co^{+3}$ ;  $Ru^{+2}$ ;  $Ru^{+3}$ ;  $Ru^{+4}$ ;  $Rh^{+3}$ ;  $Ir^{+3}$ ;  $Rh^{+2}$ ;  $Ir^{+2}$ ;  $Pd^{+4}$ ;  $Pt^{+4}$ ;  $Pd^{+2}$ ;  $Pt^{+2}$ ;  $Cu^+$ ;  $Cu^{+2}$ ;  $Cu^{+3}$ ;  $Ag^+$ ;  $Ag^{+2}$ ;  $Ag^{+3}$ ;  $Au^+$ ;  $Au^{+2}$ ;  $Au^{+3}$ ;  $Zn^{+2}$ ;  $Al^{+3}$ ;  $Ga^{+3}$ ;  $Ga^+$ ;  $In^{+3}$ ;  $In^+$ ;  $Ge^{+4}$ ;  $Ge^{+2}$ ;  $Sn^{+4}$ ;  $Sn^{+2}$ ;  $Sb^{+3}$ ;  $Sb^{+5}$ ;  $Bi^{+3}$ ;  $Bi^{+5}$ ; organic compounds containing at least one  $N^+$  site; organic compounds containing at least one phosphonium site; organic compounds containing at least one stibonium site; organic compounds containing at least one oxonium site; organic compounds containing at least one sulfonium site; organic compounds containing at least one iodonium site; quaternary ammonium compounds having a formula  $NR_4^+$ , where R is an alkyl, aromatic, or acyclic organic constituent; or combinations thereof.

152. The conversion coating bath of claim 149 wherein the solubility control agent is the anionic solubility control agent selected from fluorotitanates, chlorotitanates, fluorozirconates, chlorozirconates, fluoroniobates, chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates, fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates, chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates, fluoroaluminates, chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates, nitrates, nitrites, azides, cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates, thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates, chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates, fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates, iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides, cyanocobaltates, cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates, cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates, thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates, cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates, nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates, tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates, tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates,

(thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides,  
amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates,  
imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates,  
tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides,  
5 amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates,  
diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates,  
stibonates, cyanides, cyanochromates, cyanonickelates, cyanatochromates, cyanatonickelates,  
thiocyanatochromates, thiocyanatonickelates, cyanamidochromates, cyanamidonickelates,  
nitritonickelates, arsonates, diarsonates, triarsonates, organic selenates, diselenates, triselenates,  
10 arsenates, arsenites, fluoroarsenates, chloroarsenates, selenates, selenites, fluorothallates,  
chlorothallates, iodo mercury anions, chloromercurates, bromomercurates, osmates,  
fluoronickelates, chromates, Reinecke's salt, vanadates, or combinations thereof.

153. The conversion coating bath of claim 152 wherein the anionic solubility control agent is  
15 selected from fluorotitanates, chlorotitanates, fluoro zirconates, chloro zirconates, fluoroniobates,  
chloroniobates, fluorotantalates, chlorotantalates, molybdates, tungstates, permanganates,  
fluoromanganates, chloromanganates, fluoroferrates, chloroferrates, fluorocobaltates,  
chlorocobaltates, fluorozincates, chlorozincates, borates, fluoroborates, fluoroaluminates,  
chloroaluminates, carbonates, silicates, fluorosilicates, fluorostannates, nitrates, nitrites, azides,  
20 cyanamides, phosphates, phosphites, phosphonates, phosphinites, thiophosphates,  
thiophosphites, thiophosphonates, thiophosphinites, fluorophosphates, fluoroantimonates,  
chloroantimonates, sulfates, sulfites, sulfonates, thiosulfates, dithionites, dithionates,  
fluorosulfates, tellurates, fluorides, chlorides, chlorates, perchlorates, bromides, bromates,  
iodides, iodates, periodates, heteropolyanions, ferricyanides, ferrocyanides, cyanocobaltates,  
25 cyanocuprates, cyanomanganates, cyanates, cyanatoferrates, cyanatocobaltates, cyanatocuprates,  
cyanatomanganates, thiocyanates, thiocyanatoferrates, thiocyanatocobaltates,  
thiocyanatocuprates, thiocyanatomanganates, cyanamides, cyanamidoferrates,  
cyanamidocobaltates, cyanamidocuprates, cyanamidomanganates, nitritoferrates,  
nitritocobaltates, azides, (thio)carboxylates, di(thio)carboxylates, tri(thio)carboxylates,  
30 tetra(thio)carboxylates, (thio)phenolates, di(thio)phenolates, tri(thio)phenolates,  
tetra(thio)phenolates, (thio)phosphonates, di(thio)phosphonates, tri(thio)phosphonates,

(thio)phosphonamides, di(thio)phosphonamides, tri(thio)phosphonamides, amino(thio)phosphonates, diamino(thio)phosphonates, triamino(thio)phosphonates, imino(thio)phosphonates, diimino(thio)phosphonates, (thio)sulfonates, di(thio)sulfonates, tri(thio)sulfonates, (thio)sulfonamides, di(thio)sulfonamides, tri(thio)sulfonamides, amino(thio)sulfonates, diamino(thio)sulfonates, triamino(thio)sulfonates, imino(thio)sulfonates, diimino(thio)sulfonates, (thio)borates, di(thio)borates, (thio)boronates, organic silicates, stibonates, or combinations thereof.

154. The conversion coating bath of claim 132 wherein the conversion coating bath has a concentration of cerium, praseodymium, or terbium of between about  $1 \times 10^{-4}$  moles/liter cerium, praseodymium, or terbium and a concentration which is a maximum solubility of the cerium, praseodymium, or terbium in the solvent at a temperature of the conversion coating bath.

155. The conversion coating bath of claim 135 wherein the conversion coating bath has a concentration of oxidizer of between a minimum concentration wherein a majority of the cerium, praseodymium, or terbium is oxidized to a tetravalent oxidation state and a maximum solubility of the oxidizer in the solvent at a temperature of the conversion coating bath.

156. The conversion coating bath of claim 143 wherein the conversion coating bath has a concentration of preparative agent between a minimum concentration wherein there is a fluoride-to-cerium, fluoride-to-praseodymium, or fluoride-to-terbium ratio of 0.05 and a maximum concentration which is a maximum solubility of the preparative agent in the solvent at a temperature of the conversion coating bath.

157. The conversion coating bath of claim 145 wherein the conversion coating bath has a concentration of preparative agent between a minimum concentration, wherein there is an acidic species-to-cerium, acidic species-to-praseodymium, or acidic species-to-terbium ratio of 0.05 and a maximum concentration, which is a maximum solubility of the preparative agent in the solvent at a temperature of the conversion coating bath.

158. The conversion coating bath of claim 147 wherein the conversion coating bath has a concentration of valence stabilizer between a minimum concentration wherein there is a valence stabilizer-to-cerium, valence stabilizer-to-praseodymium, or valence stabilizer-to-terbium ratio of 0.010 and a maximum concentration which is a maximum solubility of the valence stabilizer in the solvent at a temperature of the conversion coating bath.

159. The conversion coating bath of claim 132 wherein the conversion coating bath has a pH of between about -1.5 and about 7.

160. The conversion coating bath of claim 159 wherein the conversion coating bath has a pH of between about 1 and about 6.

161. The conversion coating bath of claim 132 wherein the conversion coating bath has a temperature of between about 5°C and about 100°C.

162. The conversion coating bath of claim 161 wherein the conversion coating bath has a temperature of between about 5°C and about 40°C.

163. A corrosion-inhibiting conversion coating comprising a rare earth element and a valence stabilizer combined to form a rare earth/valence stabilizer complex, wherein  
the rare earth element is selected from cerium, praseodymium, terbium, or a combination thereof,  
at least one rare earth element is in the tetravalent oxidation state, and  
the rare earth/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.

164. A method of making a corrosion-inhibiting conversion coating bath comprising:  
providing a solvent;  
providing a rare earth source selected from a cerium source, a praseodymium source, a terbium source, or a combination thereof, wherein at least one rare earth source is in the tetravalent oxidation state;



providing a valence stabilizer; and

combining the rare earth source and the valence stabilizer to form a rare earth/valence stabilizer complex, wherein the rare earth/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.

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165. A method of applying a corrosion-inhibiting conversion coating, comprising:

providing a substrate to be coated;

contacting the substrate with a first conversion coating bath comprising a first solvent and a rare earth source, wherein

10 the rare earth source is selected from a cerium source, a praseodymium source, a terbium source, or a combination thereof, and

at least one rare earth source is in the tetravalent oxidation state; and

contacting the substrate with a valence stabilizer to form a coating comprising a rare earth/valence stabilizer complex, wherein the rare earth/valence stabilizer complex is sparingly  
15 soluble in water at about 25°C and about 760 Torr.

166. A corrosion-inhibiting conversion coating bath comprising a solvent, a rare earth source, and a valence stabilizer combined to form a rare earth/valence stabilizer complex, wherein

20 the rare earth source is selected from a cerium source, a praseodymium source, a terbium source, or a combination thereof,

at least one rare earth source is in the tetravalent oxidation state, and

the rare earth/valence stabilizer complex is sparingly soluble in water at about 25°C and about 760 Torr.